# Fluid Overload in Peritoneal Dialysis Patients

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**Summary:** Volume management in peritoneal dialysis patients is of importance, as both volume overload and dehydration are associated with worse outcomes. When assessing volume status, it is important to understand that different techniques measure different fluid compartments (intracellular vs extracellular vs circulating volume) and the impact of cardiac function. Attention to salt restriction and diuretics can help to maintain euvolemia without need for hypertonic bags. Glycaemia should be monitored to avoid thirst. Dwell length should be adapted to transport status: short dwells for fast transporters, long dwells in slow transporters. The role of bio-compatible solutions on volume control remains controversial.
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When discussing fluid status in peritoneal dialysis (PD) patients, it is important to remember that fluid can accumulate in different compartments. It is most important to make a distinction between intracellular and extracellular water, whereby the latter is to be divided in the circulating and interstitial compartments. Intracellular water (ICW) is associated directly and linearly with muscle mass. In adipose tissue, the obligatory associated water is found mainly in the extracellular compartment, which results in an increasing extracellular water to total body water (ECW/TBW) ratio because fat mass goes up in obese people, and this is irrespective of hydration status. Fluid volume in the circulating compartment is most relevant for direct cardiovascular consequences, mainly hypertension and pulmonary congestion. The causes and clinical consequences of fluid accumulation might be different between these different compartments, and the method used to assess the fluid status also will impact which compartment mainly is targeted and thus will influence the final results, explaining in part the poor correlation between the different methods to assess volume status.[1] It thus is important to take into account which compartment has been assessed when interpreting results or making clinical decisions based on assessments of volume status.

Evidence points out that in PD patients, fluid overload is present mostly in the extracellular non-circulating compartment.[2]

It also is important to use consistent terminology when talking about fluid status of PD patients.[3] Fluid balance is the difference between the volume of dialysis fluid drained from and that instilled into the patient. It should not be used to indicate the absolute fluid status/hydration status of the patient. Overhydration, normohydration, and dehydration should be used for qualitative descriptions of fluid status, whereas fluid overload in liters is suitable to quantify the amount of overhydration (positive number) or dehydration (negative number).[3] Volume status should be used only to qualitatively describe the fluid present in the circulating (plasma) compartment.

## EPIDEMIOLOGY OF FLUID STATUS IN PD

Fluid overload (FO), common in PD patients, is linked directly to increased cardiovascular (CV) morbidity and mortality. Congestive heart failure, which accounts for approximately 5% of all-cause mortality in prevalent dialysis patients, is associated closely with fluid overload, although other major CV events also could be affected by it.[4] However, volume control is a modifiable risk factor.[5]

Adequacy of peritoneal dialysis in Mexico (ADEMEX) showed no survival advantage of an increased dose of small-molecule clearance delivered by PD, but found an association of fluid overload and mortality.[6] All these have shifted the focus of dialysis adequacy from small-solute clearance to volume control.[7] The International Society of Peritoneal Dialysis (ISPD) guideline recommends regular clinical assessment of hydration status. It also recommends that hypertensive PD patients should have their volume status optimized before starting an antihypertensive treatment.[8]

Fluid status in PD patients can be assessed in different ways, and the prevalence of fluid overload varies depending on which method was used. The initiative for patient outcomes in dialysis - peritoneal dialysis (IPOD-PD) study of 1,092 patients from 135 centers in 32 countries investigated the baseline hydration status in

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incident PD patients,[3] finding that the majority (56.4%) of patients was overhydrated already before the start of PD. Symptomatic fluid retention based on clinical signs was noted in 25% of PD patients.[9] Common clinical manifestations included peripheral edema (100%), pulmonary congestion (80%), pleural effusions (76%), and systolic (83%) and diastolic (66%) hypertension.[7] When fluid status was assessed using a bioimpedance spectroscopy device in a cross-sectional cohort (European Body Composition Monitoring study (EuroBCM) cohort) of prevalent PD patients in 6 European countries, only 40% of 639 patients were normovolemic, with 25.2% being severely fluid overloaded.[10] By using bioimpedance spectroscopy, ECW/TBW of 0.40 or greater was found in 205 (66.8%) of 307 Chinese chronic ambulatory PD (CAPD) patients.[11] More than a third (36.6%) of PD patients were overhydrated, but without hypertension or other clinical signs, as assessed by the 90th percentile of a cohort of age-matched kidney transplantation patients.[12] Fluid overload as determined by bioimpedance spectroscopy (overhydration (OH)) of 1.5 L or more was detected in 60.5% of clinically stable PD patients, with 73.1% being subclinical,[13] whereas in asymptomatic Chinese PD patients, 88 of 122 (72.1%) had overhydration of 1 L or more and 25 (20.5%) had 5 L or more.[14] Based on chest ultrasound, moderate to severe lung congestion was detected in a significant proportion (46%) of asymptomatic PD patients (New York Heart Association class I).[15]

## FLUID STATUS IN PD VERSUS HEMODIALYSIS

Peritoneal dialysis provides slow but continuous ultrafiltration. This might be an advantage because it might imply an improved quality of life for patients to be allowed a relatively liberal dietary intake of salt, potassium, phosphate, protein, and fluid. However, in the opinion of most clinicians, fluid overload is thought to be more common in PD than in HD patients. In contrast to this widespread belief, most studies comparing peritoneal versus hemodialysis patients find that fluid overload is similar in both modalities.[16-18] In other studies, fluid overload was more expressed in PD versus HD patients. In one cross-sectional study of 76 prevalent patients (43 HD and 33 PD), the OH/ECW ratio assessed by the bioimpedance spectroscopy device was significantly higher in PD patients compared with post-HD patients.[19] In another cross-sectional study of 104 prevalent patients, FO was even slightly more expressed in PD compared with pre-HD.[20] The relationship between fluid status as estimated by bioimpedance analysis and plasma albumin is different between PD and HD patients. Although worsening of fluid status as determined by BIA was correlated strongly to a reduced plasma albumin level in both dialysis modalities, the association was much stronger in PD patients.[21]

To date, it has not been clarified why maintenance of euvolemia seems to be less easy in peritoneal dialysis as compared with HD. A lower compliance rate with dietary salt and fluid restriction has been suggested, because thirst is more common in PD.[22] Diabetes further aggravates thirst distress in PD patients, explaining the increased rate of FO in diabetic PD patients. Furthermore, although HD patients normally make routine visits of three times a week and have their fluid volume and dry weight controlled, stable PD patients make less than one monthly contact with the health professionals.

The 24-hour sodium removal was higher in CAPD versus automatic PD (APD) patients, and there was a trend toward better hypertension control in the CAPD group.[23] This may result in a difference in volume status. However, no reliable data are available to support the presence of a difference in fluid status between APD and CAPD. In an observational, cross-sectional study of 158 prevalent patients (90 CAPD, 68 APD), there was no difference in the extracellular fluid volume (ECFE)/TBW ratio between CAPD (51.8%) and APD (51.9%) patients ($P = .929$).[24] In another cross-sectional study of 200 prevalent patients assessed by bioimpedance spectroscopy, there was no difference between CAPD and APD in ECF volume, height-adjusted ECF volume, or the ECFV/TBW ratio.[25] CAPD was shown to be superior to APD in evaluation of left ventricular mass index and ultrafiltration.

## CLINICAL CONSEQUENCES OF FLUID STATUS IN PD

Fluid overload in peritoneal dialysis patients is associated with mortality, particularly CV mortality.[26,27] The overhydration index as measured by bioimpedance spectroscopy was an independent predictor of mortality when body mass index and lean tissue index were included in a multivariate model.[27] In a cross-sectional study, fluid overload as assessed by bioimpedance was an independent predictor of all-cause mortality and technique failure in CAPD patients.[11] In a retrospective study of 227 incident PD patients, ECF/intracellular fluid (ICF) was a strong predictor of survival, with a relative risk of death of 1.4 for every increment of 0.1 in the ECF/ICF value[28] (Fig. 1).

Hypervolemia, identified by the inferior vena cava index, decrease of inferior vena cava diameter on deep inspiration (collapsibility index), and anemia contributed independently to left ventricular geometry in CAPD patients.[29] PD patients with fluid overload tend to have increased left ventricular mass index, left ventricular end-diastolic dimension, left ventricular end-systolic dimension, and decreased left ventricular ejection fraction and fractional shortening.[30] Sustained